DOCUMENT RESUME

ED 482 001 SP 041 786

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| AUTHOR | Fletcher, Mike; Santoli, Susan |
| TITLE | Reading To Learn Concepts in Mathematics: An Action Research Project. |
| PUB DATE | 2003-00-00 |
| NOTE | 27p. |
| PUB TYPE | Reports - Research (143) |
| EDRS PRICE | EDRS Price MF01/PC02 Plus Postage. |
| DESCRIPTORS | *Academically Gifted; Algebra; Calculus; *Mathematical Concepts; *Mathematics Education; Problem Solving; *Reading Skills; Secondary Education; Secondary School Mathematics; Writing Skills |


ABSTRACT

This article summarizes research conducted in Gifted Algebra I and Gifted Precalculus classes in a public, suburban high school in spring 2002, which investigated the importance of reading and writing in understanding mathematical principles. The classroom teacher supplemented traditional numerical problem solving with vocabulary quizzes, reading assignments, and problems which required the students to explain the processes they would use and why in answering math problems. Results of this project showed substantial increases in comprehension of the reasoning behind math concepts and problems in both experimental groups as opposed to the control group. Nine appendixes include: sources for reading, vocabulary checklist surveys, concept surveys, and survey results. (Author/SM)

Running head: READING TO LEARN CONCEPTS IN MATHEMATICS: AN ACTION RESEARCH PROJECT



# Reading to Learn Concepts in Mathematics: An Action Research Project

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Abstract

This article summarizes action research conducted in Gifted Algebra I and Gifted Precalculus classes in a public, suburban high school in Spring, 2002, which investigated the importance of reading and writing in understanding mathematical principles. The classroom teacher supplemented traditional numerical problem solving with vocabulary quizzes, reading assignments and problems which required the students to explain the processes they would use and why in answering math problems. Results of this project showed substantial increases in comprehension of the reasoning behind the math concepts and problems in both experimental groups as opposed to the control groups.

# Reading to Learn Concepts in Mathematics:

# An Action Research Project

## Introduction

Mathematics is not just about numbers. The idea that the mathematics is limited to symbol manipulation has become so accepted that the name of "numeracy" has been applied to the ability to read and interpret numbers. Mathematics is more about relationships that can be quantified by numbers. Teachers tend to detach symbol manipulation and the order of operations from mathematical concepts. Students become skilled at numerical acrobatics, but they do not understand the interrelationships of concepts. In teaching mathematics, teachers should offer students the ability to learn about the concepts and relationships underlying the numbers. When this happens, the richness of the subject will explode into many other areas and mathematics will be used as it was intended: as a problem-solving tool.

## Problem and Rationale

I teach math at a suburban high school in Mobile, Alabama. I have noticed that the students with the highest grades in math are those who can follow patterns and see logical relationships from one step to another. Too often, teachers of mathematics and mathematics textbooks present a new concept in the following manner. First, a brief situation is described in which a culturally diverse student uses the topic at hand to find a solution to a problem that might come up in the daily life of an adolescent. Next, four to five example problems follow. These examples are often completely detached from the introductory situation. Finally, a problem set is included giving them 30 to 40 problems of the same type as the given examples.

The problem with this approach is that the students learn to do the problems by mimicking the example problems. They use this mimicking approach to learning throughout the chapter and on the chapter test. Students can make high grades, surviving the lesson without ever understanding the concepts underlying the numerical acrobatics they have just learned to achieve. The attempt at relevance becomes futile because the problem situation presented had nothing to do with the mathematics, only numeracy. Relevance is a key word in education, but educators need to remember to not only make mathematics relevant to the everyday life of an adolescent, but also relevant to other topics in mathematics. At higher levels, concepts become far more abstract. The understanding of math at this point goes beyond the ability to discern the relevant information in a word problem, or to use the proper arithmetic operation. In order to understand math at this higher level, the students needs to be able to relate, categorize and describe concepts that may or may not fit nicely into a textbook word problem. To reach this level of understanding, students need the ability to read about the concepts on an abstract level. A working vocabulary is critical for this, as well as an understanding of the operations and symbols that are used. I propose that if students read about the concepts and learn the meanings of the words used to communicate mathematics, that they will retain information longer and they will be able to relate different aspects of math that they had previously seen as irrelevant or disjoint.

## Review of Literature

According to one source, there are no good math textbooks in this country (Project 2061, 2001, ¶ 2). Project 2061 was an initiative by the American Association for the Advancement of Science to reform math and science texts. This initiative rated many of the textbooks currently in use by middle and high schools. They rated mathematics and science textbooks on a rating scale based on several specific criteria. The highest rating was "Excellent." The lowest was "Little Potential for Student Learning." On their website, they listed all the criteria by which the books were evaluated (Project 2061).

One of the highest ranked series of texts was from the University of Chicago School Mathematics Project (UCSMP). This text was given the rating "Potential for Student Learning." The authors devote several pages at the beginning of each lesson to explaining the concepts. An example of this is in the UCSMP's Geometry text. They devote almost 3 full pages to explain Cavalieri's Principle, which is fundamental to understanding the process of finding the volumes of prisms (Coxford, et al. 1991, pp. 488-490). With this explanation, the formulas used to find volume make more sense to students. The Prentice Hall Geometry text does mention this principle, but does not give much of an explanation as to how it relates to the formula.

The books that were rated the lowest were the algebra books from Prentice Hall and Glencoe. Their rating was "Little Potential for Student Learning." This project identified several factors as weaknesses. One of these expressed weaknesses was that "No textbook does a satisfactory job of building on students' existing ideas about algebra or helping them overcome their misconceptions or missing prerequisite knowledge" (Project 2061, ¶ 1). This identifies the problem that textbooks do not offer students enough opportunities to read about the concepts in mathematics. Mobile County just adopted textbooks a few years ago. The top two choices for the Algebra 1 curriculum were the Glencoe and Prentice Hall books. They chose Glencoe.

In order for teachers in this county to overcome this deficiency, we need to offer more and better reading material, or get new textbooks. Students need to read about mathematics. They need to internalize the vocabulary so that they can apply the concepts rather than just mimic a procedure. The National Council of Teachers of Mathematics (NCTM) published what has come to be the standard of mathematics education in their document, *Principles and Standards for School Mathematics* (2000). The mathematics textbook evaluation in Project 2061 was done, primarily, according to this standard. The NCTM included a communication aspect in its standards that encourage teachers to "help students to read increasingly technical text" (NCTM, p. 351). This is included among a detailed encouragement to teachers to help students not only to read and interpret quantifiable situations, but also to develop the communication of their ideas to others.

The vocabulary of mathematics is not usually taught in schools. If students are not reading good textbooks, then they have no place to read the terms. Blessman and Myszczak (2001) found that students did not know the vocabulary necessary to express their ideas in mathematics. They also found a correlation between the lack of reading comprehension and the understanding of mathematics concepts in fifth graders. They found significant improvements in students' performance when they intervened with math journals, student-created math dictionaries, and children's literature to help reinforce the concepts.

Schoenberger and Liming (2001) found that improving mathematical vocabulary has helped students solve multi-step problems and word problems. Their research was similar to the former in their concentration on vocabulary. They found, however, that if students knew their vocabulary and how to communicate the mathematics effectively, then their problem solving skills were actually improved. They had students make math dictionaries and they used story problems that engaged students using reading.

When students read carefully, it helps them to solve problems. Schwarz (1999) used some of the same techniques that reading teachers used in the math classroom to see what affect that had on students' problem solving skills. She used some of the same techniques employed in the former studies and found a significant increase in students' ability to communicate problems and their solutions. Schwarz focused on the language used in math.

## Target Population

My research focused on studying the effects of reading on my Gifted Algebra 1 class and my Gifted Precalculus class. Both were very small with four and five students respectively. The Algebra students were freshmen with average to above average grades in all of their other classes. The Precalculus class consisted of the top five girls in the junior class. All were highly motivated students who were not used to any other grade past the first one in the alphabet. All indicated that math was a little enjoyed subject, although most of them had a significant natural ability.

## Plan of Action

My plan was to supplement my teaching strategies with as much reading as I could find or produce. I started by following the pattern used by the researchers mentioned in the review of literature. I compiled a list of about 30 of the most fundamental words for each of the classes I teach. I wanted to know how well the students understood the vocabulary from previous topics. I gave this evaluation to my classes and to the classes of other teachers who teach the same subjects.

I collected reading material related to the concepts I would be teaching over the next two weeks in both classes (Appendix A). This material covered the historical development of the topic, noted contributors, a list of vocabulary, and written explanations of the concept. Students were given quizzes to encourage them to read.

After the treatment period, I followed with an evaluation to see how well the students could communicate what they had learned. I gave the same evaluation to the other classes that took the preliminary vocabulary check.

Implementation

I began the treatment period with my vocabulary surveys (Appendixes B and C). The most frequent comment I heard was "I should know these words!" Even with a word bank provided, students had trouble with these lists. Their personal shock had the unintended benefit of providing a large degree of relevancy to my research in their minds. They were much more willing to read and participate because of their frightening lack of retention. My colleagues in both subjects received the same feedback.

The students in my Precalculus class did not receive the reading material well. They have earned their high grades for years by following the examples in the books. The old way was fine with them. They actually resented the extra material to the point that I almost terminated the experiment in this class. They found the questions I asked about the concepts to be difficult. On one occasion they came to me as a class and requested that I only give them lessons out of their textbook. My response was to lower the stress by offering the reading comprehension questions for bonus points. I knew that their motivation would drive them to do as well, but there was less pressure when they knew it was bonus. Eventually they began to study in anticipation of the questions I would ask. This led them to learn concepts and vocabulary that they would have left alone before.

The results of the first reading quiz were very bad. As they had more opportunities to write rather than give numerical answers, their responses to the questions in these quizzes improved. I did not check for spelling and grammar, except for the spelling of their vocabulary. For example, one particular spelling that I checked was the word "complement." In Algebra 1, we studied probability where the complement of a probability p is p-1. In Set Theory, which preceded probability, the complement of a set is all elements that are not in the set. After probability, we studied the complements of acute angles. All of these I contrasted with the word "compliment." This vocabulary word helped me tie together the concepts and interrelate topics in mathematics that seemed to be disconnected to the students.

My Algebra 1 class consisted of students who were not as highly motivated to get good grades. They received the extra reading much more easily. I can cautiously say that they enjoyed the reading. The concepts at this level are not as hard for students, but much more important to their foundation in math. I found that I was giving the same material in both classes because if the conceptual foundations were established in Algebra 1, then I would not have to go back over the same material or spend nearly as much time with it in Precalculus.

Functions are of particular importance in Algebra 1. In my lecture, I showed the similarities and differences between functions and the larger class of relations, to which functions belong. I offered as extra credit, a poster representing the relationship of functions to other types of relations such as tables, graphs, and numerical maps. One student came in with a beautifully illustrated Venn diagram representing all of the relations with functions. Attached to his poster was a two-page paper describing the similarities and differences among functions and relations that I described in class. He also drew his own analogy of how a function was like the instructions that came with constructing a bicycle. The domain was the parts that came in the box, and the range of the function was the bike.

At the end of the three-week period I handed out surveys in both classes. I did not prepare my classes for the surveys, with the intention of using the survey as a baseline measurement. I also knew that the other classes would not be prepared. I chose questions for the survey that I was sure my colleagues had covered. The surveys had two types of questions. There were typical textbook problems and then concept questions on the same ideas (Appendixes D and E). I expected everyone in all classes to attempt those and I expected many to do them correctly. I hoped though, that if students were going to miss them, they would also miss the associated concept questions. When I asked the teacher of the Precalculus control group to help me with the surveys, he read the questions and told me that he knew his class was not going to answer the concept questions. I asked him to encourage them to do their best.

Results

The results of the vocabulary checklist surveys were astounding (Appendixes F and G). They closely matched the results of Blessman and Myszcak (2001) correlating the lack of comprehension of mathematical concepts with the lack of reading comprehension. It is safe to say that students do not know their mathematical vocabulary and teachers need to stress it more in their lessons. I was especially astounded at my

Algebra 1 students who did not know the definitions of the words sum and product. I had my students exchange papers and check their classmates' papers in order to use this as a learning experience. Some had never had the opportunity to check their vocabulary.

The test grades among students in my class stayed high during the treatment. My tests changed drastically though. They use TI-92 calculators in class, which display the answers and perform operations that teachers normally test. The authors of the NCTM standards realized that this would be the case when they wrote their communication standards. I have followed their recommendations and changed student evaluations. My Precalculus students remarked that many of my tests were more like English tests than any of the math tests they had ever taken. I am sure that future research will show that great benefit of writing responses in math tests rather than working a list of problems.

One issue that I did not foresee was the added length of time that it would take them to finish their tests. It takes little time to take a test when all that a student has to do is calculate and write a number. These tests required them to collect their thoughts and write a cohesive response.

The results of my concept surveys from both classes were what I hoped (Appendixes H and I). A student who has an identified learning disability associated with writing affected my Algebra I results. I was not sure how drastic the effect would be. However, his score was greater than almost half of the scores in the control group. The written responses that I received from the control group showed almost no comprehension of the concepts. The best responses were from among those papers where the textbook problems were flawless. They were not trained to write responses, but that implies that they are not able to communicate what they know. It was evident among the papers from the experimental group that they were accustomed to writing because their answers were longer. I hoped they would be much longer than they were. If the point of this project were the nature and quality of a written response, more analysis could be done. For the purpose of this study, I was satisfied that they retained the information correctly.

The results in my Precalculus were drastically better. They were unsure of themselves and believed that they had not remembered enough. I was surprised to see how much and how well they had retained the information. My colleague was correct about the responses from his class. Very few of the written responses were complete. The textbook problems were all completed, and most correctly. Only a couple of papers had almost no redeeming virtue. As with the Algebra I students, I expected more quantity from my students than what they showed in the evaluation. What they did write was correct, and upon further reflection they admitted they could have written more.

Implications

This is certainly something that I will continue in my classes. Within this period, I also changed the way I taught my Algebra II class. I have never been happy with the way I have taught conic sections, but I knew of no other way to do it. I used one of my reading sources to let them read about conic sections and their uses in telescopes, bridge construction and kidney stone removal. It made life much more interesting for all of us.

With some topics it is very easy to integrate reading and writing, but in others it takes much more time. In this treatment period I taught everything in this manner and it slowed me down tremendously. I mentioned that to one of my classes and I got a very clear response. A girl said, “Yes, but Mr. Fletcher, everyone in the other class is failing.”

This was an overstatement, but it is clear that at least this student felt like she had a clearer idea of what was going on.

Reading, writing and communicating is a hard workout in a mathematics class. Just like with any workout, there is sacrifice and sweat, but the rewards are a healthier and stronger understanding of the mathematics. There is nothing to write about if students do not know the relationships among ideas and the underlying concepts that they practice when they do textbook problems. When students write, they draw upon a different model. They use the written model that either the teacher or the authors of a good textbook have provided to explain what they know. If they do not have that model, then they are certainly at a disadvantage when asked to communicate what they know. This is a style that I will continue because I think it has improved my teaching and the ability of my students to understand mathematics.

## Appendix A
## Sources for Reading

1. Gullberg, Jan. Mathematics: From the Birth of Numbers. W. W. Norton & Company, New York, 1997.

Algebra:
The Origins of Reckoning, pp. 3-4
Numbers and Numerals, pp. 5-6
Number Names, pp. 7-25
Etymology of English Number Names, pp. 26-28
Numbers vs. Infinity, p. 29

Precalculus:
Trigonometry: Scope and History, pp. 458-469

2. Anderson, S., Brown, S., Eddins, S., Epp, S., Feldman, C. H., Flanders, J., Hackworth, M., Hirschhorn, D., McConnell, J. W., Polonsky, L., Sachs, L., Senk, S., Usiskin, Z., Widerski, T., & Woodward, E. (2002). The University of Chicago School Math Project Algebra Integrated Mathematics. Glenview, IL: Prentice Hall.

Probability and Relative Frequency p. 368-375

3. Aksoy, D., Birky, G., Brown, S., Ellis, W., Epp, S., Hollowell, K., McRill, G., Peressini, A., Sorteberg, J., Thompson, D., & Usiskin, Z. (1992). The University of Chicago School Math Project Precalculus and Discrete Mathematics. Glenview, IL: Scott, Foresman and Company.

Precalculus:
The Logic of Equation Solving (Nonreversible Operations) pp. 152-159
Reciprocals of the Power Functions pp. 302-306
Rational Functions pp. 307-312
End Behavior of Rational Functions pp. 314-320
Analyzing Logarithmic Functions pp. 122-127
Analyzing the Sine and Cosine Functions pp. 129-135

Mathematical Biographies

Algebra 1
*John Venn Diagram Designer.* (1995) Historical Connections Volume 3. AIMS Educational Foundation. Pp. 62-63.

*Pascal Launcher of the Computer Age*. (1992) Historical Connections in Mathematics. AIMS Educational Foundation. Pp. 48-49.

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Blessman, J., & Myszczak, B. (2001). *Mathematics vocabulary and its effect on student comprehension*. St. Xavier University.

Coxford, A., Hirschhorn, D., & Usiskin, Z. (1991). *The university of Chicago school math project geometry.* Glenview, IL: Scott, Foresman and Company.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics.* Reston, Va.: NCTM.

*Project 2061.* (2000). Retrieved February 11, 2002, from http://www.project2061.org/newsinfo/research/textbook/hsalg/outcome.htm

Schoenberger, K., & Liming, L. (2001). *Improving students' mathematical thinking skills through improved use of mathematics vocabulary and numerical operations.* St. Xavier University.

Schwarz, J. (1999). *Vocabulary and its effects on mathematics instruction.* St. Xavier University.

MacTutor History of Mathematics Archive

Hipparchus (Trigonometry)
http://www-history.mcs.st-and.ac.uk/history/Mathematicians/Hipparchus.html
Trigonometric Functions
http://www-history.mcs.st-and.ac.uk/history/HistTopics/Trigonometric_functions.html

# Appendix B
## Algebra I Vocabulary Checklist Survey

Fill in the blank with the appropriate math term. Consult the bank below if necessary. There are more words in the bank than there are spaces.

1. The result when adding numbers _______________
2. The result when subtracting numbers__________________
3. The result when multiplying numbers__________________
4. The result when dividing numbers_____________________
5. The bottom number in a fraction_____________________
6. The top number in a fraction___________________
7. The set of all numbers that make an equation true________________
8. The symbol used to indicate a square root_______________
9. The number of times a number is used as a factor in a product_______________
10. When a number is in two sets at once, it is in the _____________of the sets
11. When a number is in either one set or the other, it is in the _____________of the sets
12. A diagram that represents the relationships of sets__________________
13. The set from which the input values of a function are drawn________________
14. The set of numbers to which a function maps_______________
15. A relation between sets that maps an element from the domain to only one element of the range_______________
16. A function whose rate of change is constant___________
17. A function that outputs –x when x is negative and when x is non-negative____________
18. When the product of two numbers is one, then the numbers are ______________
19. When the sum of two numbers is the additive identity, the numbers are _______________
20. The ratio of events that can occur to the total number of possible events_______________
21. The largest number that will divide evenly into a pair of numbers________________
22. The smallest number that two numbers divide into equally___________________
23. Since a times b is equal to b times a, then multiplication is said to be ______________
24. A rectangular array of numbers_____________________
25. The ratio of the circumference of a circle to its diameter________________
26. The number of times an event occurs__________________
27. The y-value of a relation when the x-value is zero___________________
28. The word that describes the point (0,0)______________________
29. The horizontal axis on the coordinate plane_____________________
30. The vertical axis on the coordinate plane____________________
31. One-half and two-fourths are called _____________fractions
32. A line segment that passes through the center of a circle having endpoints on the circle

| | | | |
|---|---|---|---|
| domain | matrix | Venn Diagram | degree |
| range | absolute value | base | power |
| least common multiple (LCM) | function | exponent | extraneous solutions |
| | quadratic function | exponential function | probability |
| greatest common factor (GCF) | function | pi | communtative |
| | frequency | denominator | associative |
| continuous | intersection | undefined | distributive |
| discrete | additive inverses | sum | least common denominator (LCD) |
| linear function | product | arcsine | |
| diffrence | union | multiplicative inverse | y-intercept |
| x-axis | quotient | origin | equal |
| y-axis | numerator | equivalent | diameter |

Please underline your answers to the following questions:

1. My first language is English. (yes, no)
2. I had to refer to the word back to find the answer for (a few of, about half, most all) of the answers.
3. I am (better, as good, not as good) with the computations that I am with the related vocabulary.
4. I (never, sometimes, always) read the lesson in the textbook before attempting the problems in that section.

# Appendix C
## Precalculus Vocabulary Checklist Survey

Fill in the blank with the appropriate math term. Consult the bank below if necessary. There are more words in the bank than there are spaces.

1. The result when adding numbers_______________
2. The result when subtracting numbers___________________
3. The result when multiplying numbers___________________
4. The result when dividing numbers_____________________
5. The symbol used to indicate a square root___________________
6. The function which returns the exponent to which a base is raised____________________
7. The number of times a number is used as a factor in a product____________________
8. The number in an exponential function that is used as a factor___________________
9. When a number is in two sets at once, it is in the ___________________of the sets
10. When a number is in either one set or the other it is in the _______________of the sets
11. A diagram that represents the relationship of sets______________________
12. The set from which the input values of a function are drawn____________________
13. The set of number to which a function maps______________________
14. A relation between sets that maps an element from the domain to only one element of the range____________
15. A function whose rate of change is constant___________________
16. A function that outputs –x when x is negative and x when x is non-negative________________
17. When the graph of a function has no holes, it is said to be _____________________
18. When the graph of a function is not continuous, then it is ______________________
19. The ratio of the opposite side to the hypotenuse of a right triangle___________________
20. The ratio of the adjacent side to the hypotenuse of a right triangle___________________
21. The ratio of the opposite side to the adjacent side of a right triangle__________________
22. The ratio of the adjacent side to the hypotenuse of a right triangle_________________
23. The function that outputs an angle when the sine of an angle is given_________________
24. If function values approach a value in the range as x goes to infinity, that number is called a ________of the function
25. The line of the graph of a function that the y-values approach, but never touch, as the x-values increase_________________
26. The highest exponent in a polynomial is the _______________of the polynomial
27. When the product of two numbers is one, then the numbers are _________________
28. When the sum of two numbers is the additive identity, the numbers are ______________
29. When algebraic solutions result that do not satisfy the original equation, the solutions are_____________
30. The ratio of the circumference of a circle to its diameter____________________

| | | | |
|---|---|---|---|
| domain | tangent | Venn diagram | arctangent |
| range | absolute value | base | vertical asymptote |
| sine | function | exponent | horizontal asymptote |
| cosine | quadratic function | exponential function | degree |
| continuous | function | logaritum function | power |
| discrete | intersection | arccosine | extraneous solutions |
| linear function | additive inverses | undefined | pi |
| secant | product | sum | independent |
| cosecant | union | arcsine | dependent |
| cotangent | quotient | multiplicative inverses | inconsistent |
| difference | determinant | discriminant | consistent |
| | inverse function | root | |

Please underline your answers to the following questions:

5. My first language is English. (yes, no)
6. I had to refer to the word back to find the answer for (a few of, about half, most all) of the answers.
7. I am (better, as good, not as good) with the computations that I am with the related vocabulary.
8. I (never, sometimes, always) read the lesson in the textbook before attempting the problems in that section.

Appendix D
Algebra I Survey

Name the number set(s) to which each of the following belong:

1. 3/5 ________________
2. –5 _________________

Evaluate if $f(x) = 2x + 3$

3. $f(2)$
4. $f(6)$

5. Find the range of $f(x) = 2x + 3$ if the domain is $\{0, 1, 2, 3\}$.

6. Graph $f(x) = 2x + 3$ if the domain is the set of whole numbers.

7. What is a function?

8. What is the difference between the statement $f(x) = 2x + 3$ and $u = 2x + 3$?

Appendix E
Precalculus Survey

Please answer the following as clearly and concisely as you can.

1. Give the horizontal and vertical asymptotes for the graph of $y = \frac{2x^2}{x^2+7x+12}$

2. What is the difference between a horizontal asymptote and the limit of a function?

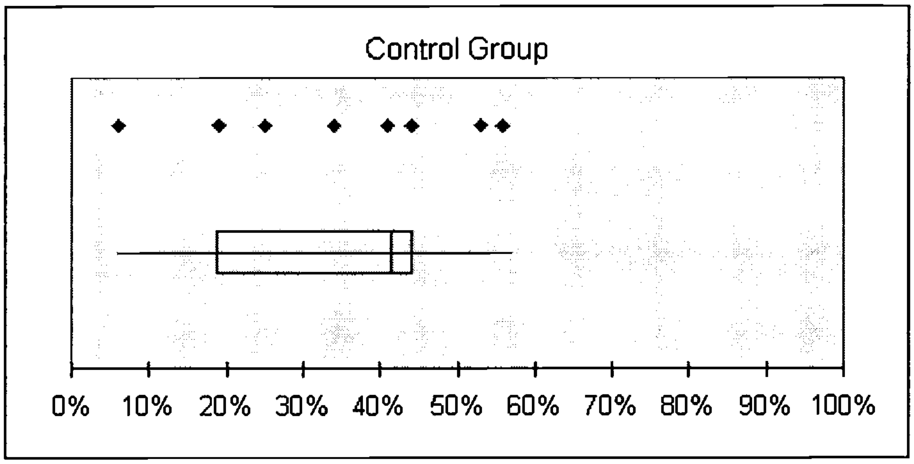
3. Solve $\in$ABC if C is the right angle. A = 42°, c = 25°

4. Describe the significance of the unit circle in trigonometry.

Appendix F
Preliminary Vocabulary Survey Results for Algebra I

**Box Plot**

| Data | Rank |
|---|---|
| 56% | 1 |
| 53% | 2 |
| 44% | 3 |
| 44% | 4 |
| 44% | 5 |
| 44% | 6 |
| 44% | 7 |
| 41% | 8 |
| 41% | 9 |
| 41% | 10 |
| 41% | 11 |
| 34% | 12 |
| 25% | 13 |
| 19% | 14 |
| 19% | 15 |
| 19% | 16 |
| 19% | 17 |
| 19% | 18 |
| 6% | 19 |

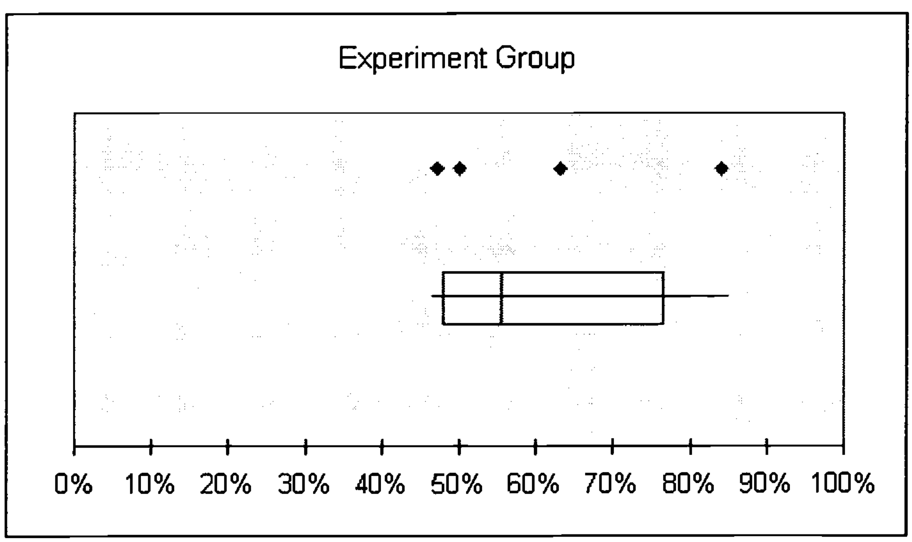



*Smallest = 0.06*
*Q1 = 0.19*
*Median = 0.41*
*Q3 = 0.44*
*Largest = 0.56*
*IQR = 0.25*

**Box Plot**

| Data | Rank |
|---|---|
| 84% | 1 |
| 63% | 2 |
| 50% | 3 |
| 47% | 4 |

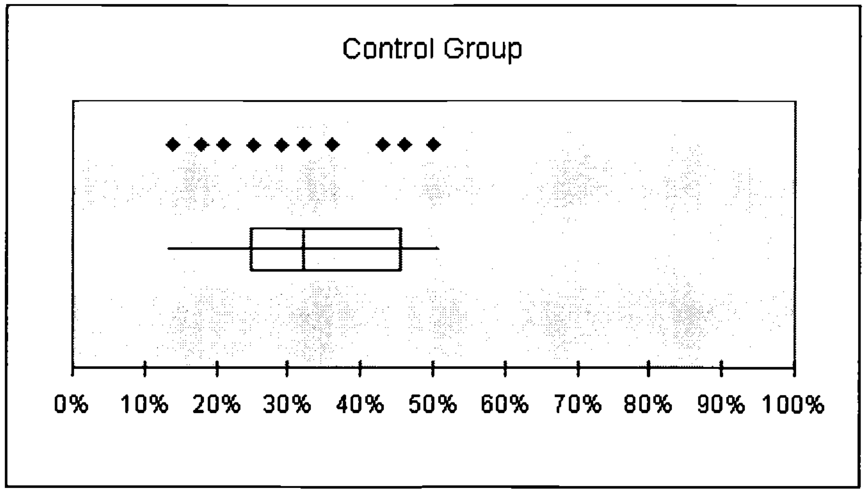
*Smallest = 0.47*
*Q1 = 0.4775*
*Median = 0.565*
*Q3 = 0.7875*
*Largest = 0.84*
*IQR = 0.31*



Appendix G
Preliminary Vocabulary Survey Results for Precalculus

**Box Plot**

| Data | Rank |
|---|---|
| 50% | 1 |
| 50% | 2 |
| 46% | 3 |
| 46% | 4 |
| 46% | 5 |
| 46% | 6 |
| 46% | 7 |
| 43% | 8 |
| 43% | 9 |
| 43% | 10 |
| 36% | 11 |
| 32% | 12 |
| 32% | 13 |
| 29% | 14 |
| 29% | 15 |
| 29% | 16 |
| 29% | 17 |
| 29% | 18 |
| 25% | 19 |
| 21% | 20 |
| 18% | 21 |
| 18% | 22 |
| 18% | 23 |
| 14% | 24 |

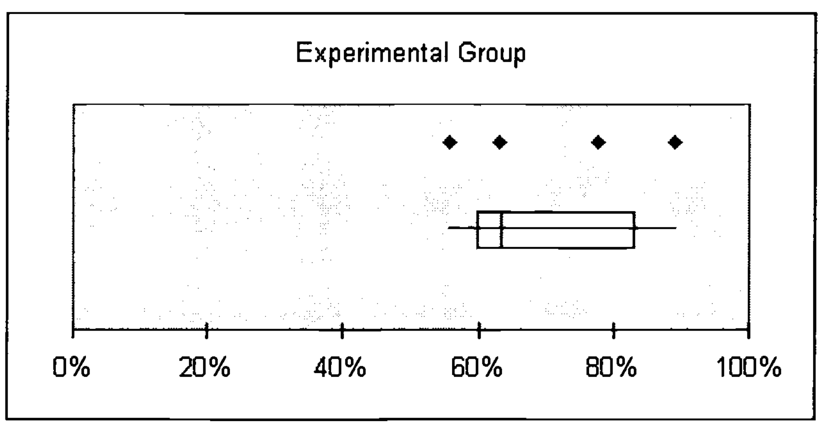



*Smallest = 0.14*
*Q1 = 0.26*
*Median = 0.32*
*Q3 = 0.46*
*Largest = 0.5*
*IQR = 0.2*

**Box Plot**

| Data | Rank |
|---|---|
| 89% | 1 |
| 78% | 2 |
| 63% | 3 |
| 63% | 4 |
| 56% | 5 |

*Smallest = 0.56*
*Q1 = 0.59*
*Median = 0.63*
*Q3 = 0.83*
*Largest = 0.89*
*IQR = 0.24*

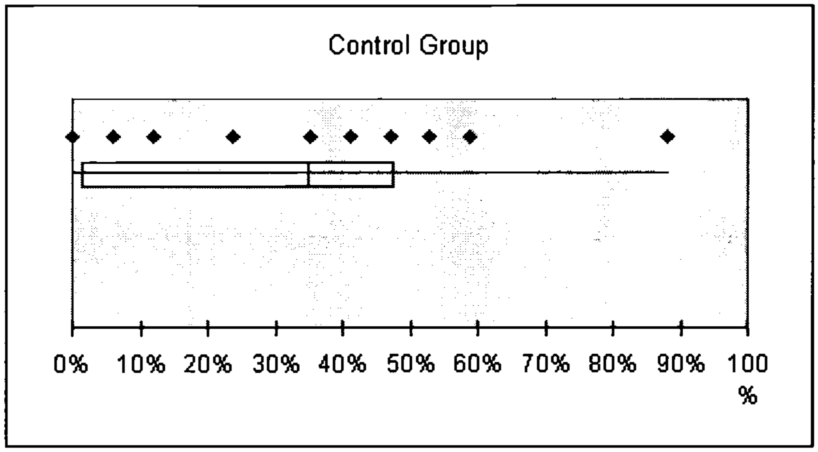


Appendix H
Concept Survey Results for Algebra I

**Box Plot**

| *Data* | *Rank* |
|---|---|
| 88% | 1 |
| 59% | 2 |
| 53% | 3 |
| 47% | 4 |
| 47% | 5 |
| 47% | 6 |
| 41% | 7 |
| 35% | 8 |
| 35% | 9 |
| 24% | 10 |
| 12% | 11 |
| 6% | 12 |
| 0% | 13 |
| 0% | 14 |
| 0% | 15 |
| 0% | 16 |

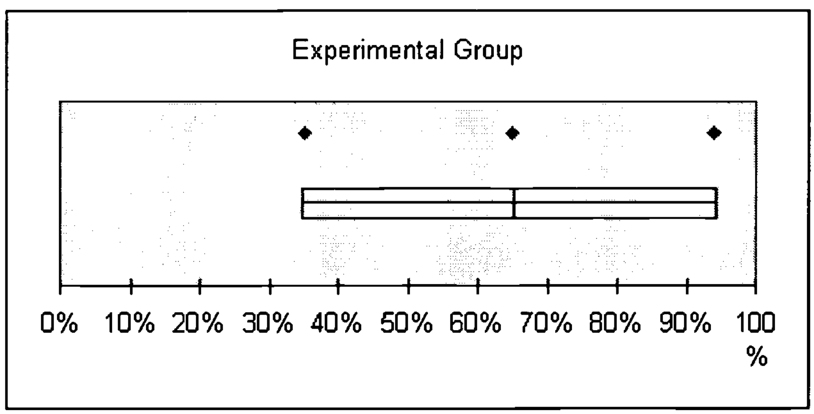
*Smallest = 0*
*Q1 = 0.01*
*Median = 0.35*
*Q3 = 0.47*
*Largest = 0.88*
*IQR = 0.46*




**Box Plot**

| *Data* | *Rank* |
|---|---|
| 94% | 1 |
| 65% | 2 |
| 35% | 3 |

*Smallest = 0.35*
*Q1 = 0.35*
*Median = 0.65*
*Q3 = 0.94*
*Largest = 0.94*
*IQR = 0.59*

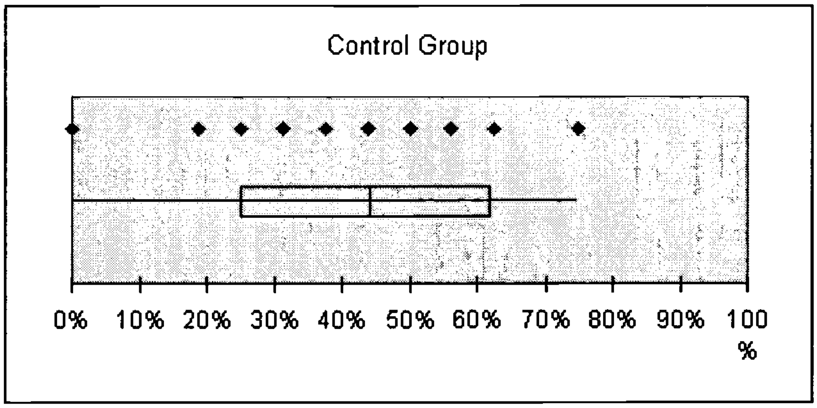


Appendix I
Concept Survey Results for Precalculus

**Box Plot**

| *Data* | *Rank* |
|---|---|
| 75% | 1 |
| 63% | 2 |
| 63% | 3 |
| 63% | 4 |
| 63% | 5 |
| 63% | 6 |
| 63% | 7 |
| 56% | 8 |
| 50% | 9 |
| 50% | 10 |
| 44% | 11 |
| 38% | 12 |
| 38% | 13 |
| 31% | 14 |
| 31% | 15 |
| 25% | 16 |
| 25% | 17 |
| 25% | 18 |
| 19% | 19 |
| 0% | 20 |

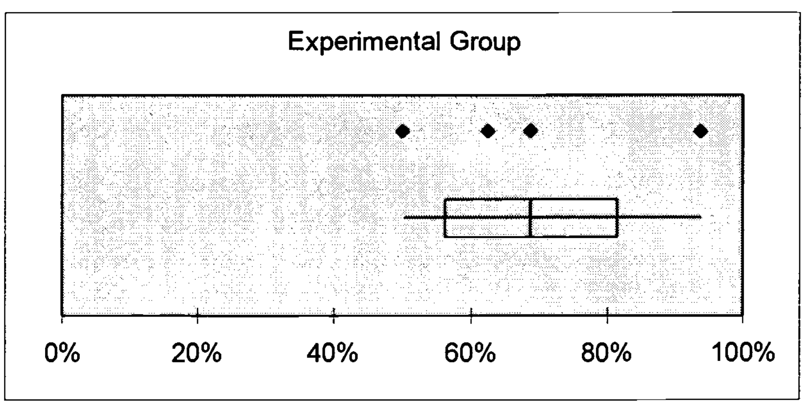
*Smallest = 0*
*Q1 = 0.27*
*Median = 0.47*
*Q3 = 0.63*
*Largest = 0.75*
*IQR = 0.36*




**Box Plot**

| *Data* | *Rank* |
|---|---|
| 94% | 1 |
| 69% | 2 |
| 69% | 3 |
| 63% | 4 |
| 50% | 5 |

*Smallest = 0.5*
*Q1 = 0.56*
*Median = 0.69*
*Q3 = 0.81*
*Largest = 0.94*
*IQR = 0.25*



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Title: Reading to Learn Concepts in Mathematics: An Action Research Project

Author(s): Mike Fletcher, Susan Santoli (Editor)

| Corporate Source: | Publication Date: |
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